FU19 *Nephrops* grounds 2020 UWTV survey report and catch scenarios for 2021.

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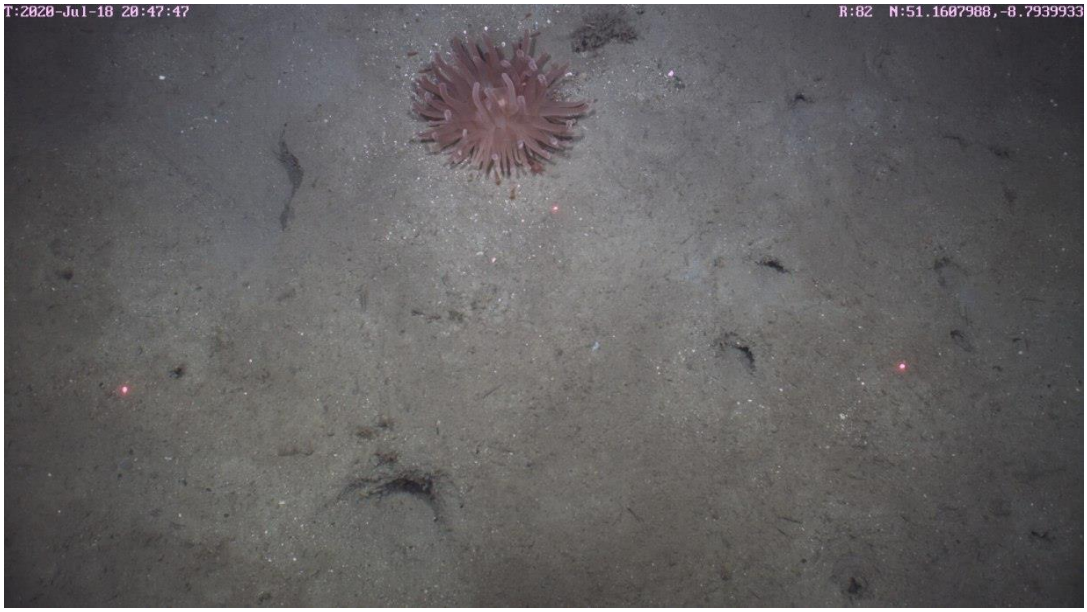

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Abstract

This report provides the main results of the eleventh underwater television survey of the various *Nephrops* patches in Functional Unit 19. The survey was multi-disciplinary in nature collecting UWTV, multi-beam and other ecosystem data. In 2020 a total 42 UWTV stations were successfully completed. The mean density estimates varied considerably across the different patches. The 2020 raised abundance estimate was a 20% decrease from the 2019 estimate and at 320 million burrows is below the MSY $B_{trigger}$ reference point (430 million). Using the 2020 estimate of abundance and updated stock data implies catch in 2021 that correspond to the F ranges in the EU multi annual plan for Western Waters are between 531 and 595 tonnes (assuming that discard rates and fishery selection patterns do not change from the average of 2017–2019). Two species of sea pen were observed; *Virgularia mirabilis* and *Pennatula phosphorea* which have been observed on previous surveys of FU19. Trawl marks were observed at 26% of the stations surveyed.

Key words: *Nephrops norvegicus,* stock assessment, geostatistics, underwater television (UWTV), benthos.

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Introduction

Nephrops norvegicus are common in the Celtic Sea occurring in geographically distinct sandy/muddy areas were the sediment is suitable for them to construct their burrows. The *Nephrops* fishery in ICES sub-area 7 is extremely valuable with Irish landings in 2019 worth around €42 million at first sale. The Celtic Sea area (Functional Units 19-22) supports a large multi-national targeted *Nephrops* fishery mainly using otter trawls and yielding landings in the region of ~5,000 t annually. Over the last decade reported landings from FU19 have been at around 580 t (ICES, 2019). The 2019 landings of around 249 t are estimated to be worth €1.4 m at first sale. The *Nephrops* fishery in FU19 occurs on several spatially discrete patches of suitable habitat which are spread out over a large area (Figure 1).

Nephrops spend a great deal of time in their burrows and their emergence behaviour is influenced by many factors; time of year, light intensity and tidal strength. Underwater television surveys and assessment methodologies have been developed to provide a fishery independent estimate of stock size, exploitation status and catch advice for several *Nephrops* stocks around Ireland (ICES, 2009, 2011).

The 2020 survey was multi-disciplinary in nature and also covered TV stations in FU17 and FU22 the results of which are presented elsewhere (Doyle *et. al*., 2020, Aristegui *et al.,* 2020a). The specific objectives of 2020 survey are listed below:

1. To obtain 2019 quality assured estimates of *Nephrops* burrow densities from several of the discrete mud patches of *Nephrops* ground in FU19.
2. To compare burrow density estimates with those made by previous surveys.
3. To collect ancillary information from the UWTV footage collected at each station such as the occurrence of sea-pens, other macro benthos and fish species and trawl marks on the sea bed.

This report details the final UWTV results of the 2020 FU19 survey and also documents other data collected during the survey. Operational survey details are available in the form of a survey narrative from the scientists in charge. The 2020 abundances are used to generate catch scenarios for 2021 in line with the recommendations and procedures outlined in the stock annex for FU19 (ICES, 2020).

Material and methods

The spatial extent of the *Nephrops* grounds in FU19 has been defined using 2006-2014 integrated VMS-logbook data using the methods described in Gerritsen and Lordan (2011) along with using multi-beam backscatter data from seabed mapping programmes (ICES, 2014). The discrete patches have been named as: Bantry Bay, Galley Ground 1-4, Cork Channels and Helvick 1 & 2 (Figure 1). The area of each ground polygon is shown in Table 1 as defined by WKCELT (ICES, 2015). *Nephrops* also occur outside these defined polygons in areas such as Kenmare Bay which was surveyed for the sixth time this year (2 stations completed).

In 2020 UWTV stations were randomly picked within each patch using the "spsample" function from the "R" library "sp" (Pebesma & Bivand, 2005) of "R" (R Core Team, 2017). The planned stations are shown in Figure 2. Previously stations were randomly chosen using the "Create Random Points" tool in ArcToolbox of ArcGIS10. The sampling effort, i.e. the numbers of stations, on each ground were determined relative to the spatial extent of each patch, as in previous years.

The 2020 FU19 survey took place over two legs on RV. Celtic Voyager from 9th to 7th July and 9th to 21st July. Surveys in other years were generally between June to September (Figure 2).

In 2020 image data was collected by a custom built camera system recording High Definition still image data at 12 frames per second with a camera angle of 75 (°). The digital images were stored on a server and reviewed ashore after the survey, using an inhouse developed Image annotation R Shiny app (Aristegui, 2020b). This application allows each reviewer to annotate burrows for each randomly assigned station in an efficient manner. The survey process is now paperless.

The operational protocols used were those reviewed by the Workshop on the use of UWTV surveys for determining abundance in *Nephrops* stocks throughout European waters (ICES, 2007) and employed on other UWTV surveys in Irish waters. These protocols can be summarised as follows: At each station the UWTV sledge was deployed. Once stable on the seabed a 10 minute tow was recorded. Time referenced high definition image data were collected with a field of view or 'FOV' of 1.01 metre. Vessel position (DGPS) and position of sledge (using a USBL transponder) were recorded every 3 seconds. The navigational data were quality controlled using an "R" script developed by the Marine Institute (ICES, 2009b). In 2020 the USBL navigational data was used to calculate distance over ground for all of the stations. Station depths ranged from 39 metres on Helvick grounds to 130 metres on the Galley Grounds.

In line with recommendations of the Study Group on *Nephrops* Surveys (SGNEPS; ICES, 2012) all scientists were trained/re-familiarised using 2020 image data as training material prior to recounting ashore. There is no FU19 specific reference footage available in standard or high definition format. All counts were conducted by trained scientists independent of each other after the survey ashore.

All counts were conducted by four trained scientists independent of each other after the survey. The numbers of *Nephrops* burrows systems were counted, where multiple burrows in close proximity which appear to be part of a single system were counted as one. *Nephrops* activity in and out of burrows were counted and recorded for each station. Following the recommendation of SGNEPS the time for verified recounts was 7 minutes (ICES, 2009b).

Presence / absence notes were also recorded on the occurrence of trawl marks, fish species and other species. Presence / absence of sea-pen species were also recorded to fulfil an OSPAR Special Request (ICES 2011).

Finally, if there was any time during each minute where counting was not possible, due to sediment clouds or other reasons, this was recorded and removed from the distance over ground calculations. The "R" quality control tool allowed for the data quality of navigation, speed, visual clarity and consistency in counts to be checked (an example is given in Figure 3).

In 2020 the survey count data was screened to check for any unusual discrepancies using Lin's Concordance Correlation Coefficient (CCC) with a threshold of 0.5. Lin's CCC (Lin, 1989) measures the ability of counters to exactly reproduce each other's counts on a scale of 1 to -1 where 1 is perfect concordance (i.e. a pairwise plot will have all points lying along the 1:1 line. A value of -1 would be generated by all points lying on the -1:1 line and a value of 0 indicates no correspondence at all. Lin's CCC quality control plots of count data for stations 303 and 305 are shown in Figure 4. When the count data fell below the threshold of 0.5 a third review was carried out. The paired count data that passed the Lin's CCC threshold was used in the analysis. When the paired counts did not pass the threshold, an average of the three reviewers was deemed appropriate to use in the analysis.

Mean density was calculated by dividing the total number of burrow systems by the survey area observed. The USBL positional data was used to calculate distance over ground of the sledge. The field of view of the camera at the bottom of the screen was estimated by extrapolation at 1.01 m assuming that the sledge was flat on the seabed (i.e. no sinking). Occasionally the lasers were not visible at the bottom of the screen due to sinking in very soft mud, the impact of this is a minor under estimate of densities at stations where this occurred.

A global mean density and summary statistics (number of stations, standard deviation, standard error, 95% confidence intervals and CV) were estimated for all stations. Mean Density was multiplied by the total area given in Table 1 to estimate the raised abundance estimate along with confidence intervals. All analysis was carried out using "R" (R Core Team, 2017). The same approach has been used since 2015. Prior to 2013 some other adjustments were made to account for incomplete survey coverage. Details of these are given in previous survey reports (Lordan, *et al.*, 2013).

Results

The summary statistics for the various discrete *Nephrops* patches within FU19 are given in Table 2. The 2020 mean adjusted[1] burrow density estimates vary considerably, from the lowest observed at Helvick 2 of 0.06 (burrows/m²) to the highest of 0.43 (burrows/m²) at Galley Grounds 2. The mean density for most patches showed a decrease compared with 2019. Bubble plots of densities over the

[1] Note the "adjusted" density estimates in this report are adjusted by dividing by 1.3 to take account of edge effect over estimation of area viewed during UWTV transects (see Campbell et al 2009).

time-series by discrete patch show variability across the grounds and years (Figure 5). The adjusted burrow densities for each *Nephrops* patch from 2006 to 2020 are shown in Figure 6 as violin and box plots. For the most grounds the observed densities were lower in 2020 compared to the previous year.

The adjusted burrow densities for the combined FU19 grounds from 2006 to 2020 are shown in Figure 7. The 2020 mean density of 0.16 burrows/m^2 was 20% lower than 2019.

The time series of summary statistics for FU19 are given in Table 3. The 2020 raised abundance estimate of 320 million burrows is a 20% decrease from the 2019 estimate (Figure 8), and below the MSY $B_{trigger}$ reference point (430 million). The CV or RSE (relative standard error) for the 2019 survey was 15% which is below the upper limit of 20% recommended by SGNEPS (ICES, 2012).

Sea-pen distribution across the FU19 *Nephrops* grounds is mapped in Figure 9. Two species; *Virgularia mirabilis* and *Pennatula phosphorea* were identified from the image data. Trawl marks were noted at 26% of the stations surveyed.

The UWTV abundance data together with data from the fishery; landings, discards and removals in number are used to calculate the harvest rate in 2019 of 3.3%. The mean weight in the landings and the discards and the proportions of removal retained are also shown (Table 4). The basis to the catch scenarios is given in Table 5.

The catch and landings scenarios at various different fishing mortalities were calculated in line with the stock annex of the Report of the Working Group on Celtic Seas Ecoregion (ICES, 2020) using the 2020 survey abundance (Table 6). The latest estimate of stock abundance is below the MSY $B_{trigger}$ (value 430 million). The ICES MSY approach states that under such conditions the F_{MSY} harvest rate (9.3% for FU 19 Norway lobster) should be reduced by multiplying it by the ratio of the current abundance to MSY $B_{trigger.}$ This corresponds to a harvest rate of [9.3 × (320/430)] = 6.9% for the catch advice in 2021. Fishing at the EU MAP F ranges in 2020 would result in catches between 531 and 595 tonnes assuming that discard rates and fishery selection patterns do not change from the average of 2017–2019.

Discussion

The time series of UWTV survey information is developing for this Functional Unit. Several discrete mud patches with fished *Nephrops* populations have been identified and the survey coverage and precision since 2011 has been reasonable. It is clear that there are consistent differences in density in the different patches but most patches seem to vary annually in a similar way. Scientific knowledge of the spatial distribution of the *Nephrops* habitat in this area is developing thanks to new multi-beam data (www.infomar.ie), more extensive VMS data and information from the fishing industry particularly for inshore areas.

Nephrops fisheries in this area have been covered under the landings obligation since 2016 with several exemptions. Irish discard survival experiments indicate that the trawl discard survival may be around 64% (BIM*,* 2017). As a result, an exemption from the landings obligation based on high survivability has been granted by the European Commission. Discard rates for this FU are estimated to be relatively high at approximately 50% by number and 25% by weight in the last three years. The provision of catch advice and scenarios for 2021 based on the EU MAP (EU, 2019) F ranges assumes that discarding will continue at the average rate estimated between 2017and 2019.

The imposition of the landings obligation on *Nephrops* fisheries since 2016 should result in changes in selectivity in the fisheries with high discard rates like FU19. This is not taken into account in any of the catch advice because it is not possible to predict exactly what might happen. The main message is that any improvements in selectivity in the fishery and reductions in discards will result in increased mean weight in the catches. This should in turn reduce overall mortality on the stocks and allow for catch increases in the future.

An important objective of this UWTV survey is to collect ancillary information. The occurrence of trawl marks on the footage is notable for two reasons. Firstly, it makes identification of *Nephrops* burrows more difficult as the trawl marks remove some signature features making accurate burrow identification more difficult. Secondly, only occupied *Nephrops* burrows will persist in heavily trawled grounds and it is assumed that each burrow is occupied by one individual *Nephrops* (ICES 2008).

Monitoring the occurrence and frequency of sea-pens observed on these *Nephrops* patches is important in the context of OSPAR's designation of sea-pen and burrowing megafauna communities as threatened. Two sea-pen species: *Virgularia mirabilis* and *Pennatula phosphorea* were seen in 2020. These have been observed on previous surveys of FU19. Monitoring *Nephrops* stocks and the benthic habitat is also important in the context of the MFSD indicators (e.g. sea floor integrity).

The main objectives of the survey were successfully met for the eleventh time. The UWTV image data quality was excellent and in 2020 and all of the *Nephrops* patches within FU19 were successfully surveyed. The multi-disciplinary nature of the survey means that the information collected is highly relevant for a number of research and advisory applications.

Acknowledgments

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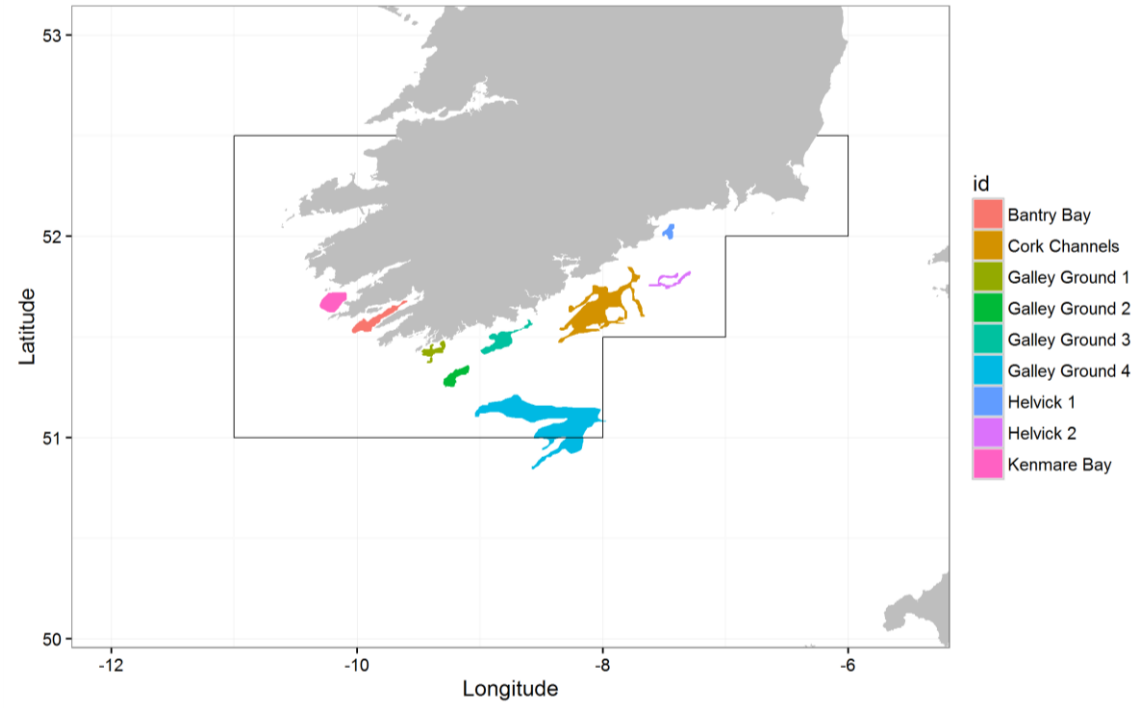

Figure 1: FU19 grounds: Individual *Nephrops* ground area polygons in Functional Unit 19.

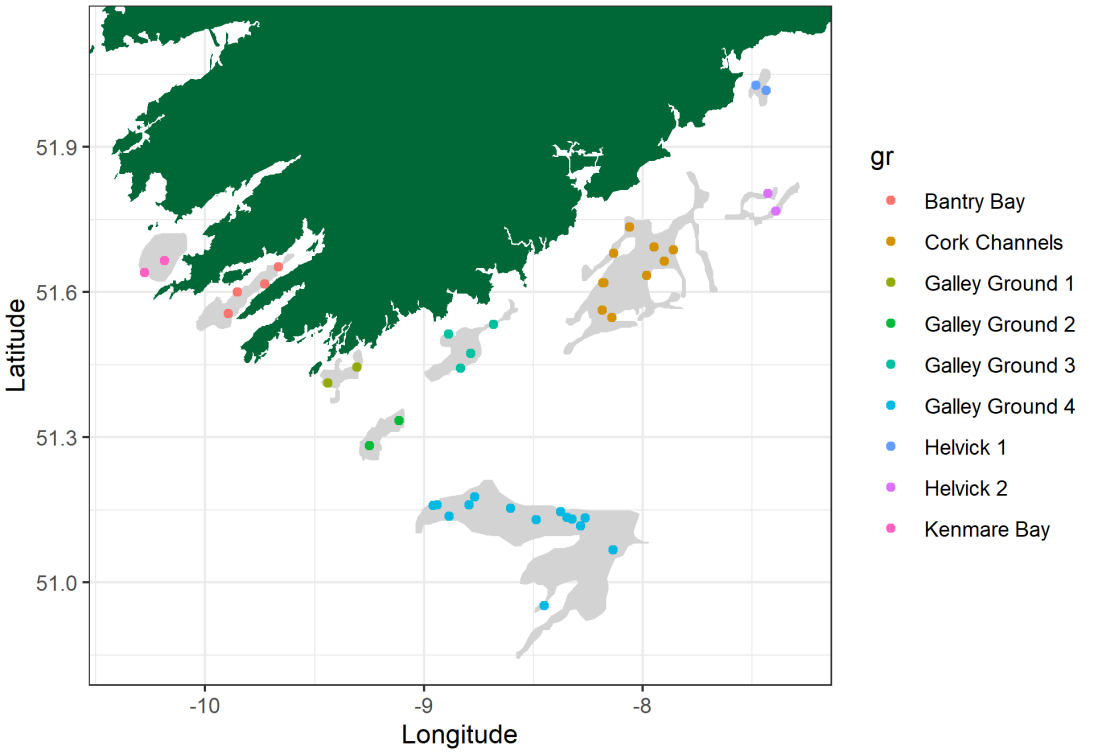

Figure 2: FU19 grounds: Stations completed on the 2020 *Nephrops* UWTV survey.

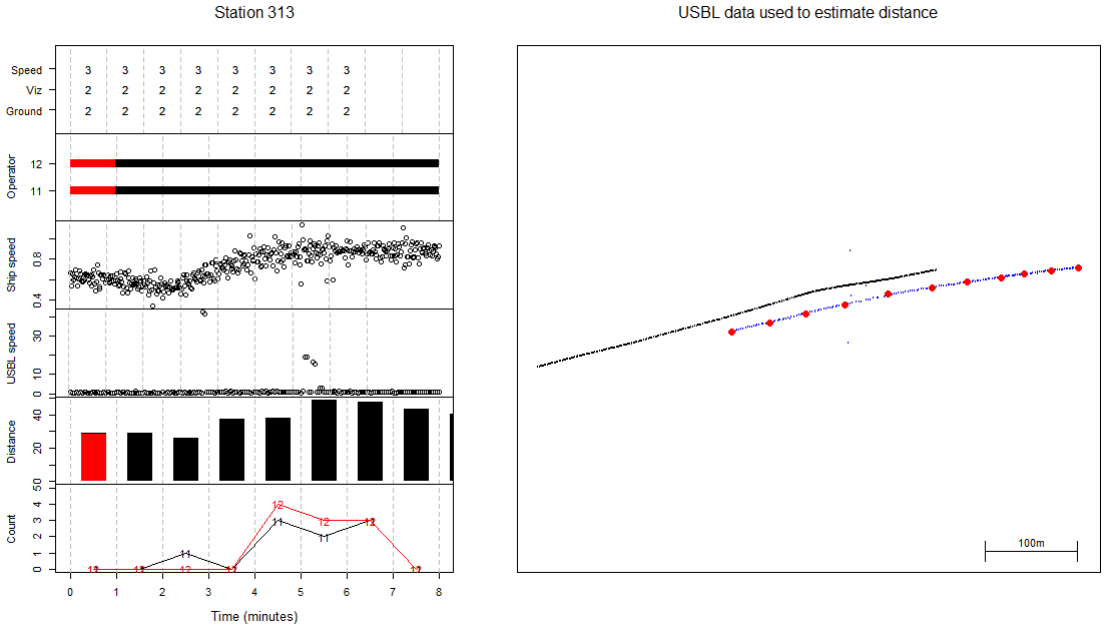

Figure 3: FU19 grounds: R - tool quality control plot for station 313 of the 2020 UWTV survey.

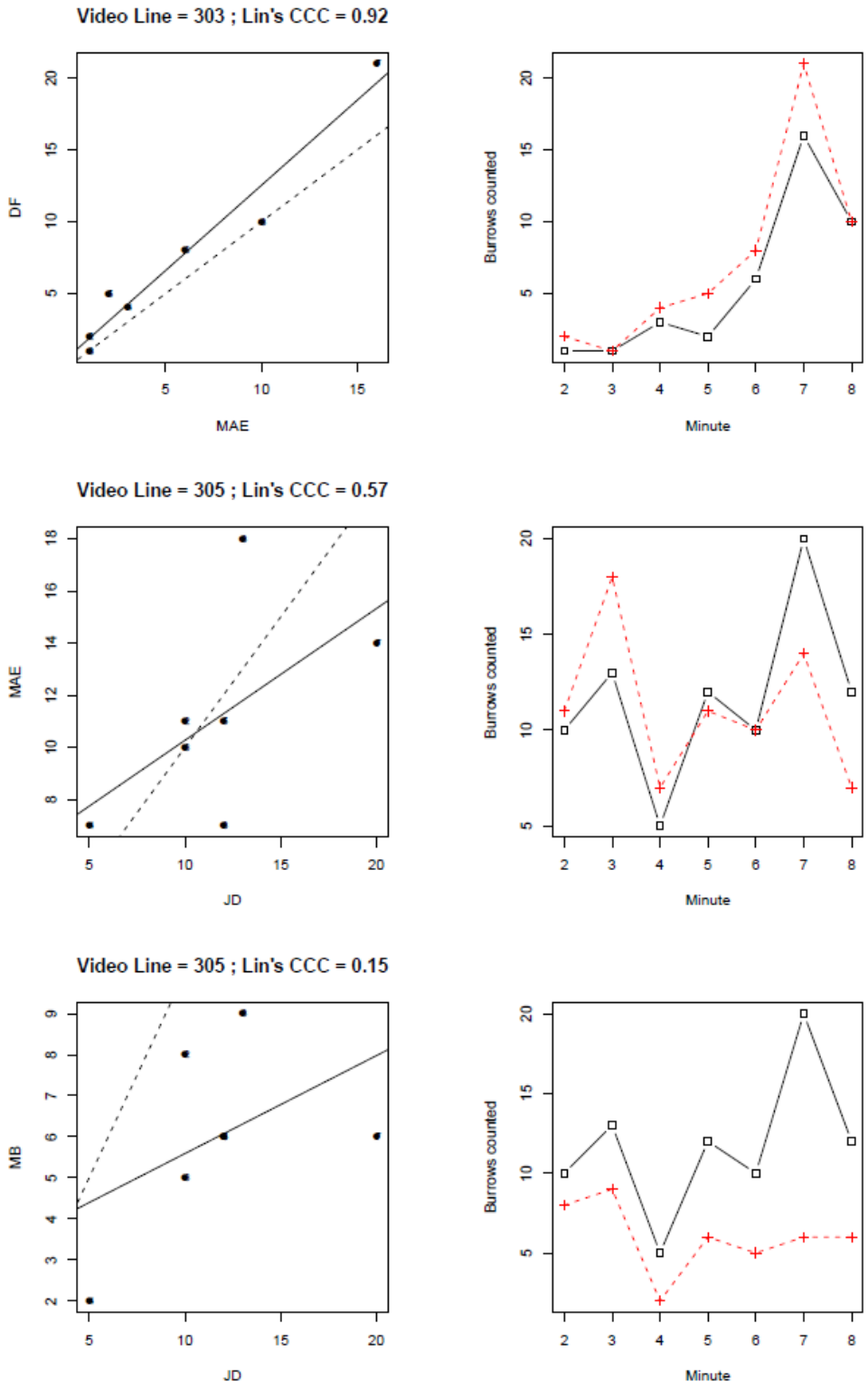

Figure 4: FU19 grounds: Lin's CCC quality control plot of count data for stations 303 and 305 of the 2020 survey.

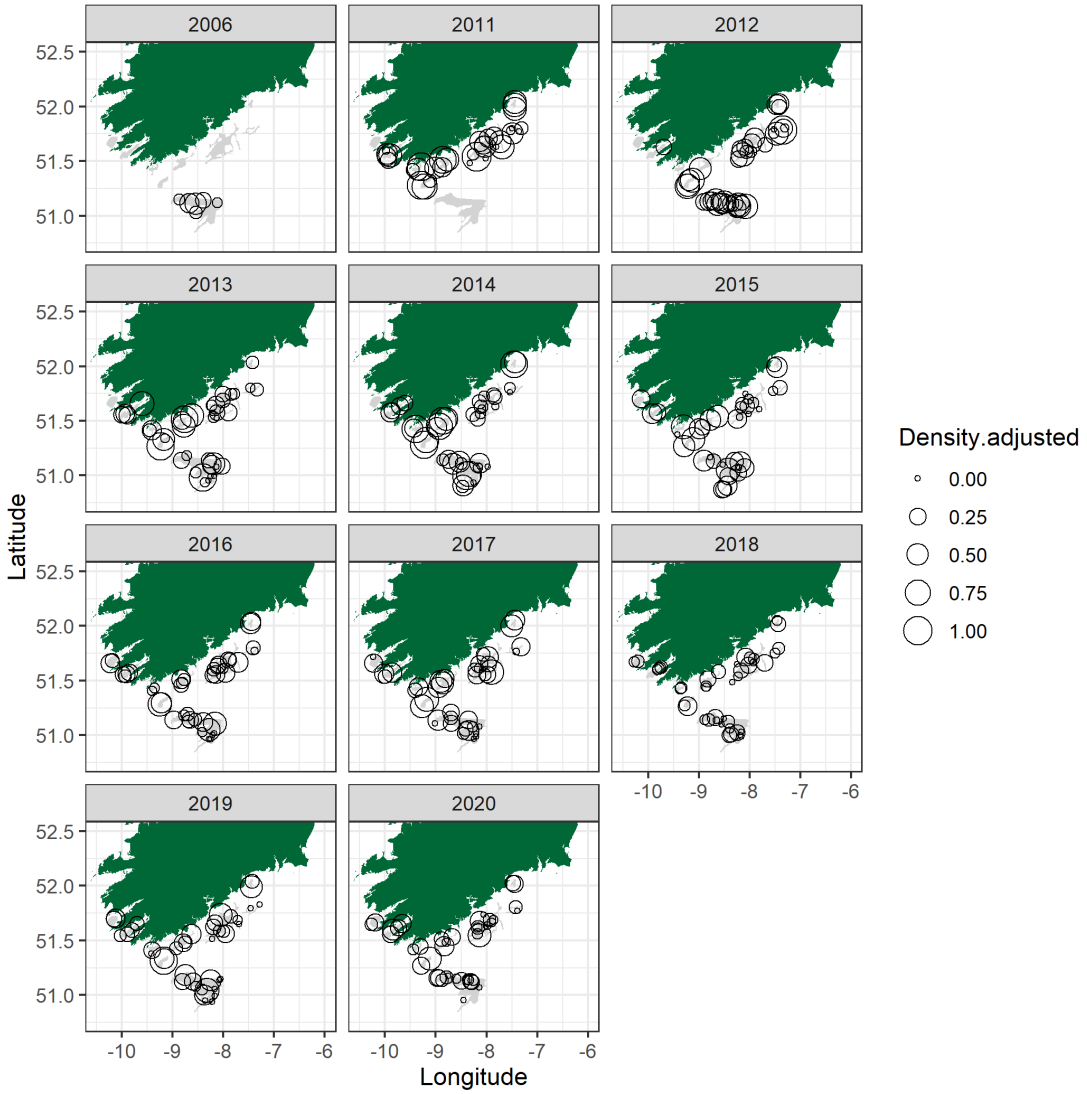

Figure 5: FU19 grounds: Bubble plot of the adjusted density (burrows/m²) from 2006 to 2020.

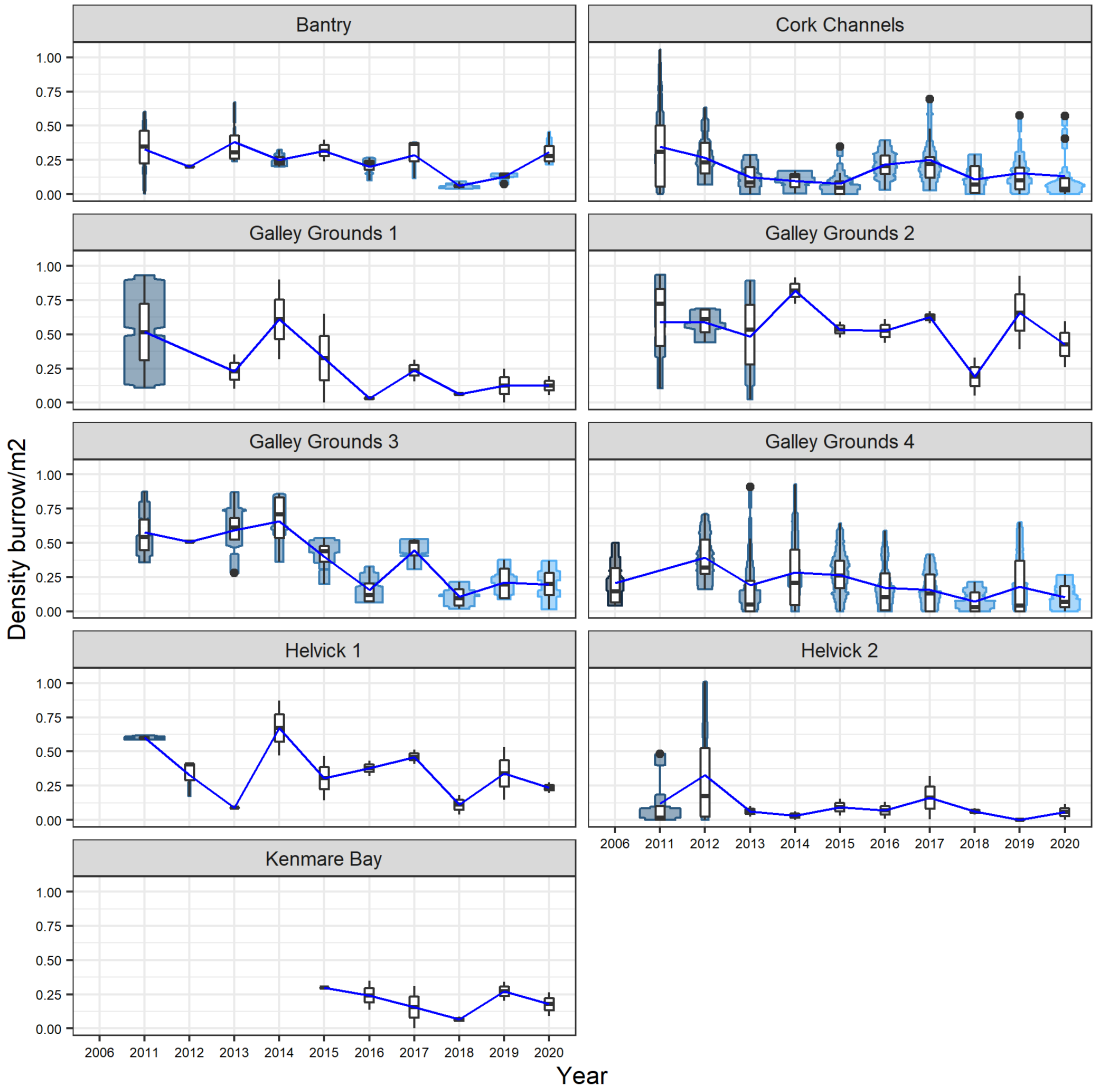

Figure 6: FU19 grounds: Violin and box plots of adjusted burrow density distributions by year for 2006-2020 for each ground. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the inter quartile range, the black vertical line is the range and the black dots are outliers. No TV survey from 2007 – 2010.

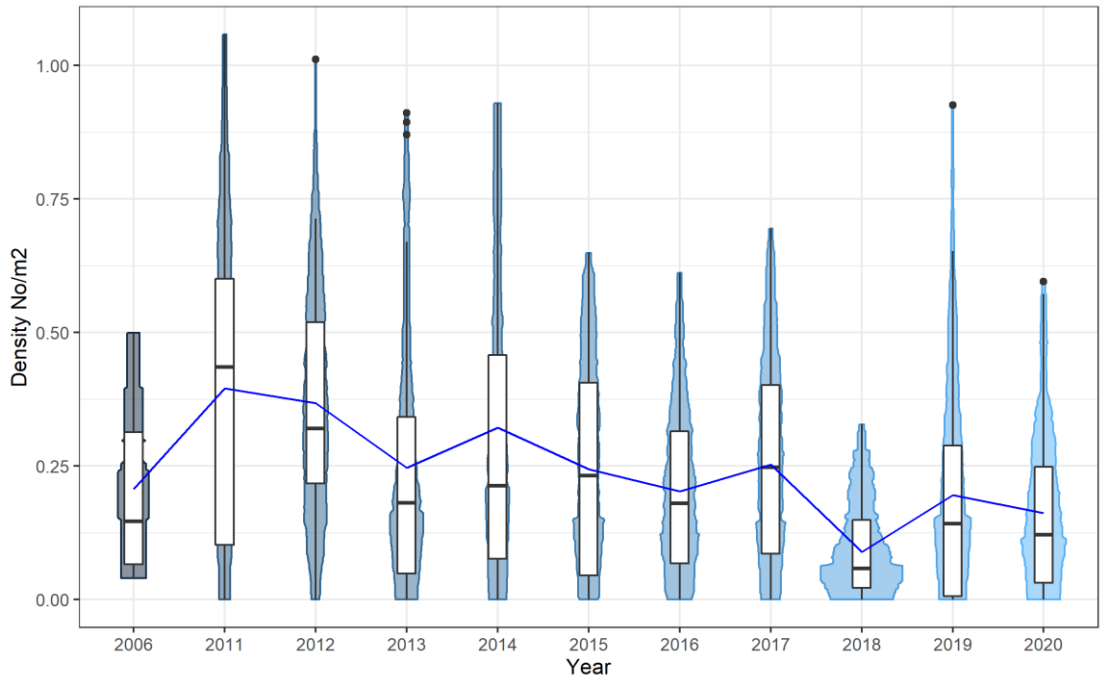

Figure 7: FU19 grounds: Combined violin and box plot of adjusted burrow density distributions by year for 2006-2020. The blue line indicates the mean density over time. The horizontal black lines represent medians, white boxes the inter quartile ranges, the black vertical lines the range and the black dots are outliers. No TV survey from 2007 – 2010.

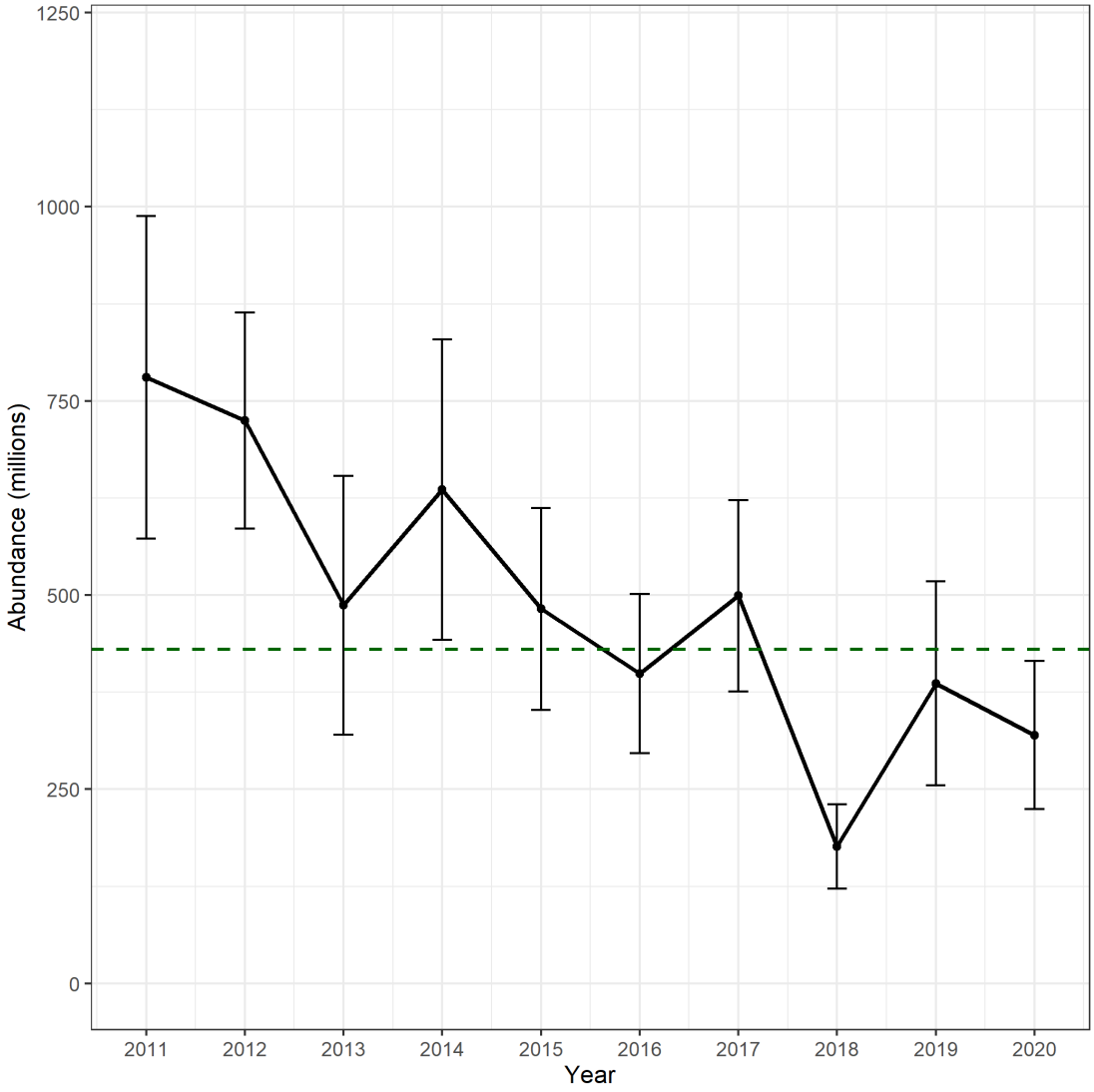

Figure 8: FU19 grounds: Time series of raised abundance estimates (in millions of burrows) for FU19. No survey data from 2007 to 2010. The error bars indicate the 95% confidence intervals and and MSY $B_{trigger}$ reference point is dashed green line.

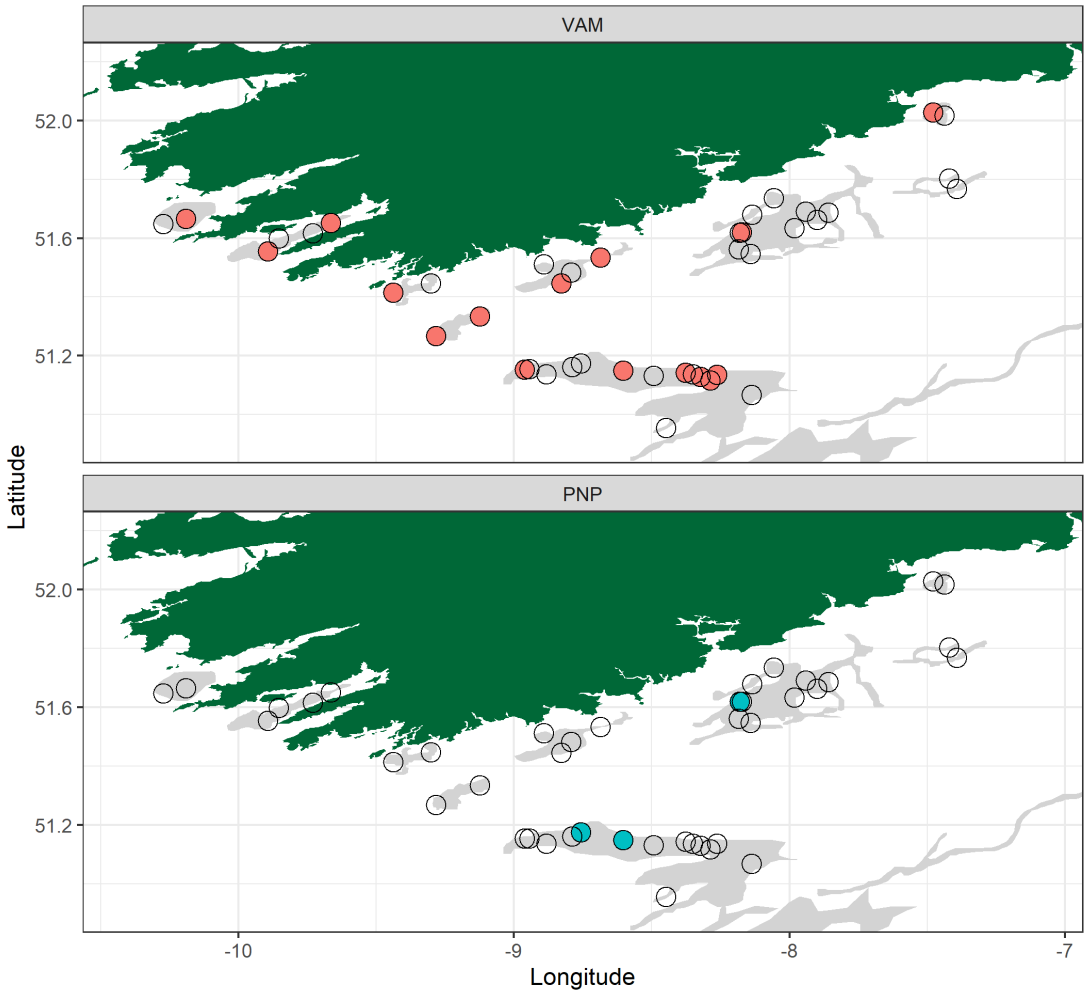

Figure 9: FU19 grounds: 2020 stations where *Virgularia mirabilis* (VAM) top panel and *Pennatula phosphorea* (PNP) bottom panel were identified and noted as present or absent. Closed circles indicated presence and open circles denotes TV stations with no sea-pen observations.

Table 1: FU19 grounds: Area calculations for the various *Nephrops* grounds in FU19 (ICES, 2014).

Ground Name	Area (km²)
Bantry	121.52
Cork Channels	562.01
Galley Grounds 1	60.86
Galley Grounds 2	76.74
Galley Grounds 3	133.94
Galley Grounds 4	925.10
Helvick 1	33.09
Helvick 2	59.52
Total	1,972.78

Table 2: FU19 grounds: Detailed summary statistics for the various *Nephrops* patches in FU19 over the time series. (N = number of stations, Mean Density (N/m^2) is adjusted for the bias correction factor, sd, se and ci are the standard deviation, standard error and 95% confidence intervals on the mean density).

Year	Ground	N	Mean Density (N/m^2)	sd	se	ci
2006	Galley Grounds 4	6	0.21	0.18	0.08	0.19
2011	Bantry	5	0.33	0.23	0.1	0.28
2011	Cork Channels	12	0.35	0.32	0.09	0.2
2011	Galley Grounds 1	3	0.52	0.41	0.24	1.02
2011	Galley Grounds 2	3	0.59	0.43	0.25	1.07
2011	Galley Grounds 3	4	0.58	0.22	0.11	0.35
2011	Helvick 1	3	0.6	0.01	0.01	0.04
2011	Helvick 2	5	0.12	0.21	0.09	0.26
2012	Bantry	1	0.2	NA	NA	NA
2012	Cork Channels	9	0.27	0.17	0.06	0.13
2012	Galley Grounds 2	4	0.59	0.12	0.06	0.19
2012	Galley Grounds 3	1	0.51	NA	NA	NA
2012	Galley Grounds 4	16	0.39	0.16	0.04	0.09
2012	Helvick 1	3	0.33	0.13	0.08	0.33
2012	Helvick 2	6	0.33	0.41	0.17	0.43
2013	Bantry	4	0.38	0.2	0.1	0.31
2013	Cork Channels	11	0.12	0.1	0.03	0.07
2013	Galley Grounds 1	2	0.23	0.18	0.13	1.59
2013	Galley Grounds 2	3	0.48	0.44	0.25	1.09
2013	Galley Grounds 3	4	0.59	0.24	0.12	0.38
2013	Galley Grounds 4	13	0.19	0.27	0.07	0.16
2013	Helvick 1	1	0.09	NA	NA	NA
2013	Helvick 2	2	0.06	0.05	0.04	0.48
2014	Bantry	4	0.25	0.05	0.03	0.09
2014	Cork Channels	10	0.1	0.06	0.02	0.04
2014	Galley Grounds 1	2	0.61	0.41	0.29	3.69
2014	Galley Grounds 2	2	0.82	0.14	0.1	1.23
2014	Galley Grounds 3	4	0.66	0.23	0.12	0.37
2014	Galley Grounds 4	14	0.29	0.29	0.08	0.17
2014	Helvick 1	2	0.67	0.28	0.2	2.53
2014	Helvick 2	2	0.03	0.04	0.03	0.39
2015	Bantry	2	0.32	0.11	0.08	1.02
2015	Cork Channels	10	0.08	0.11	0.03	0.08
2015	Galley Grounds 1	2	0.32	0.46	0.32	4.12
2015	Galley Grounds 2	2	0.53	0.08	0.06	0.74

Table 2 (cont.): FU19 grounds: Detailed summary statistics for the various *Nephrops* patches in FU19 over the time series. (N = number of stations, Mean Density (N/m²) is adjusted for the bias correction factor, sd, se and ci are the standard deviation, standard error and 95% confidence intervals on the mean density).

Year	Ground	N	Mean Density (N/m²)	sd	se	ci
2015	Galley Grounds 3	4	0.4	0.14	0.07	0.23
2015	Galley Grounds 4	14	0.27	0.19	0.05	0.11
2015	Helvick 1	2	0.3	0.23	0.16	2.08
2015	Helvick 2	2	0.09	0.09	0.06	0.79
2015	Kenmare Bay	1	0.3	NA	NA	NA
2016	Bantry	4	0.2	0.07	0.04	0.12
2016	Cork Channels	10	0.21	0.11	0.03	0.08
2016	Galley Grounds 1	2	0.03	0.01	0.01	0.08
2016	Galley Grounds 2	2	0.53	0.12	0.09	1.11
2016	Galley Grounds 3	4	0.16	0.12	0.06	0.19
2016	Galley Grounds 4	14	0.17	0.2	0.05	0.12
2016	Helvick 1	2	0.38	0.08	0.06	0.7
2016	Helvick 2	2	0.07	0.09	0.06	0.81
2016	Kenmare Bay	2	0.24	0.15	0.11	1.33
2017	Bantry	3	0.29	0.15	0.09	0.37
2017	Cork Channels	10	0.25	0.20	0.06	0.14
2017	Galley Grounds 1	2	0.24	0.11	0.08	1.00
2017	Galley Grounds 2	2	0.63	0.06	0.04	0.55
2017	Galley Grounds 3	3	0.45	0.12	0.07	0.30
2017	Galley Grounds 4	15	0.16	0.16	0.04	0.09
2017	Helvick 1	2	0.46	0.07	0.05	0.66
2017	Helvick 2	2	0.16	0.23	0.16	2.03
2017	Kenmare Bay	2	0.16	0.22	0.16	1.97
2018	Bantry	4	0.06	0.02	0.01	0.04
2018	Cork Channels	10	0.11	0.11	0.04	0.08
2018	Galley Grounds 1	2	0.06	0.01	0.01	0.10
2018	Galley Grounds 2	2	0.19	0.19	0.14	1.75
2018	Galley Grounds 3	4	0.11	0.09	0.05	0.14
2018	Galley Grounds 4	14	0.07	0.08	0.02	0.05
2018	Helvick 1	2	0.11	0.10	0.07	0.92
2018	Helvick 2	2	0.06	0.03	0.02	0.28
2018	Kenmare Bay	2	0.07	0.03	0.02	0.25
2019	Bantry	4	0.1280604	0.0372284	0.0186142	0.0592387
2019	Cork Channels	10	0.1551884	0.1749606	0.0553274	0.1251593
2019	Galley Grounds 1	2	0.1235176	0.1746803	0.1235176	1.5694399
2019	Galley Grounds 2	2	0.6584566	0.3787177	0.2677939	3.4026438
2019	Galley Grounds 3	4	0.2127944	0.1424995	0.0712498	0.2267485
2019	Galley Grounds 4	14	0.1799468	0.2259034	0.0603752	0.1304328
2019	Helvick 1	2	0.3403986	0.274094	0.1938137	2.462637

Table 2 (cont.): FU19 grounds: Detailed summary statistics for the various *Nephrops* patches in FU19 over the time series. (N = number of stations, Mean Density (N/m²) is adjusted for the bias correction factor, sd, se and ci are the standard deviation, standard error and 95% confidence intervals on the mean density).

Year	Ground	N	Mean Density (N/m²)	sd	se	ci
2019	Helvick 2	2	0	0	0	0
2019	Kenmare Bay	2	0.2702178	0.0977154	0.0690953	0.8779384
2019	Dunmanus Bay*	2	0	0	0	0
2020	Bantry	4	0.308542	0.107317	0.053658	0.170765
2020	Cork Channels	10	0.132103	0.195925	0.061957	0.140156
2020	Galley Grounds 1	2	0.125367	0.096954	0.068557	0.871097
2020	Galley Grounds 2	2	0.426898	0.237735	0.168104	2.135963
2020	Galley Grounds 3	4	0.195775	0.150655	0.075327	0.239726
2020	Galley Grounds 4	14	0.101497	0.096722	0.02585	0.055846
2020	Helvick 1	2	0.235309	0.053794	0.038038	0.483324
2020	Helvick 2	2	0.057114	0.080772	0.057114	0.725705
2020	Kenmare Bay	2	0.177257	0.124087	0.087743	1.114878

*exploratory stations

Table 3: FU19 grounds: Final of results for UWTV surveys in FU19 for 2006-2020. No UWTV survey in years 2007 to 2010.

FU	Year	Number of stations	Mean Density adjusted (burrow /m²)	Standard Deviation	Raised abundance estimate adjusted (million burrows)	Upper 95%CI on Abundance	Lower 95%CI on Abundance	CVs (%)
FU19	2006	6	0.21	0.18	408	789	26	36
	2007	No Survey Data						
	2008							
	2009							
	2010							
	2011	35	0.34	0.26	665	842	488	13
	2012	40	0.3	0.18	594	708	480	9
	2013	40	0.25	0.26	487	653	320	17
	2014	40	0.32	0.31	636	829	442	15
	2015	39	0.24	0.2	482	612	352	13
	2016	42	0.2	0.17	399	501	296	13
	2017	41	0.25	0.20	499	622	376	12
	2018	42	0.09	0.09	176	230	122	15
	2019	42	0.20	0.21	386	517	255	17
	2020	42	0.16	0.16	320	415	224	15

Table 4: FU19 grounds: Inputs to catch scenarios table.

Year	UWTV abundance estimate	95% Confidence Interval	Landings in number	Total discards in number*	Removals in number	Harvest rate (by number)	Landings	Total discards*	Discard proportion (by number)	Dead discard proportion (by number)	Mean weight in landings	Mean weight in discards
	Millions					%	tonnes		%		grammes	
2006			26	3	28		741	37	8.9	6.8	28.3	14.4
2007			31	2	32		957	26	4.8	3.6	31.1	17.0
2008			25	5	29		851	105	17.7	13.9	33.7	19.4
2009			28	19	42		868	269	39.5	32.8	30.5	14.5
2010			23	19	37		687	257	45.1	38.1	29.6	13.5
2011	665	171	26	32	50	7.5	643	409	55.7	48.5	24.9	12.6
2012	594	111	32	37	60	10.1	849	473	53.6	46.4	26.3	12.7
2013	487	161	29	36	57	11.7	794	436	55.3	48.1	26.9	11.9
2014	636	188	16	11	25	3.9	468	161	41.1	34.4	28.6	14.1
2015	482	126	17	12	26	5.4	507	167	41.1	34.3	29.8	14.1
2016	399	100	20	14	30	7.5	590	193	40.8	34.1	29.9	14.2
2017	499	120	15	10	22	4.4	420	139	39.7	33.1	28.8	14.5
2018	176	53	8	4	11	6.7	238	71	34.8	28.6	28.2	15.7
2019	386	127	7	7	13	3.3	249	112	48.2	41.1	33.6	16.3
2020	320	93										

Table 5: FU19 grounds: The basis for the catch scenarios.

Variable	Value	Notes
Stock abundance (2021)	320	Numbers of individuals (millions); UWTV survey 2020
Mean weight in projected landings	30.2	Average 2017 – 2019 in grammes
Mean weight in projected discards	15.5	Average 2017 – 2019 in grammes
Projected discards	40.9	Proportion by number; average 2017 – 2019
Discards survival*	25	Proportion by number
Projected dead discards	34.3	Proportion by number; average 2017 – 2019

*Only applied in scenarios where discarding is allowed

Table 6: Catch advice and scenarios for 2021. Discarding assumed to continue at recent average. All weights are in tonnes.

Basis	Total catch	Dead removals	Projected landings	Projected dead discards	Projected surviving discards	Harvest rate * %	% advice change **
	PL + PDD + PSD	PL + PDD	PL	PDD	PSD	for PL + PDD	
ICES advice basis							
MSY approach; F = EU MAP^: F_{MSY} × Stock Abundance 2020 / MSY $B_{trigger}$	595	556	439	117	39	6.9	-29
MAP $F_{MSY\ lower}$ × Stock Abundance 2020 / MSY $B_{trigger}$	531	496	392	105	35	6.2	-29
MAP $F_{MSY\ upper}$ × Stock Abundance 2020 / MSY $B_{trigger}$	595	556	439	117	39	6.9	-29
							Other scenarios
F = MAP F_{MSY}	801	748	590	158	53	9.3	-4.5
F = MAP $F_{MSY\ lower}$	714	668	527	141	47	8.3	-4.7
F = MAP $F_{MSY\ upper}$***	801	748	590	158	53	9.3	-4.5
F_{2019}	281	262	207	55	18	3.3	-67

^ EU multiannual plan (MAP) for Western Waters (EU, 2019).

* By number.

** Advice value for 2021 relative to the corresponding 2020 values (MAP advice value of 839, 749 and 839 tonnes, respectively; other values are relative to FMSY).

*** $F_{MSY\ upper}$ =F_{MSY} for this stock.